PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:
Sadayuki WATANABE, *et al.*

Serial No.: 10/723,182

Filed: 26 November 2003

Title: PERPENDICULAR MAGNETIC RECORDING MEDIUM AND MANUFACTURING METHOD THEREOF

Group Art Unit: 1773

Examiner: H. Rickman

Attorney Docket No.: FUJI:282

Certificate of Mailing
I hereby certify that this paper is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on:

Date: March 15, 2005

By:
Marc A. Rossi

COMMISSIONER FOR PATENTS
P.O. BOX 1450
ALEXANDRIA, VA 22313-1450

CERTIFIED ENGLISH TRANSLATION OF PRIORITY APPLICATION TO PERFECT PRIORITY

Sir:

Applicants submit a certified English translation of Japanese priority application JP 2002-342589, filed on 26 November 2002.

March 15, 2005
Date

Respectfully submitted,

ROSSI, KIMMS & McDOWELL LLP

Marc A. Rossi
Reg. No. 31,923

P.O. BOX 826
Ashburn, VA 20146-0826
703-726-6020 (Phone)
703-726-6024 (fax)

CERTIFICATE OF VERIFICATION

I, David H. Owens
of Nisihshinbashi 3 Mori Bldg. 4F, 1-4-10 Nishisinbashi, Minato-ku, Tokyo, Japan

state that the attached document is a true and complete translation to the best of my knowledge of the Reference No.02P00874.

Dated this 9 September, 2003.

Signature ______________________
David H. Owens

[Name of Document] Application for Patent

[Reference Number] 02P00874

[Filing Date] November 26, 2002

[Addressee] Director General of the Patent Office

[International Classification] G11B 5/66

[Title of the Invention] Perpendicular Magnetic Recording Medium and Manufacturing Method Thereof

[Number of Claims] 5

[Inventor]

[Address] c/o Fuji Electric Co., Ltd.
1-1, Tanabeshinden, Kawasaki-ku,
Kawasaki-shi, Kanagawa-ken

[Name] Sadayuki Watanabe

[Inventor]

[Address] c/o Fuji Electric Co., Ltd.
1-1, Tanabeshinden, Kawaaki-ku,
Kawasaki-shi, Kanagawa-ken

[Name] Yasushi Sakai

[Applicant]

[ID Number] 000005234

[Name] Fuji Electric Co., Ltd.

[Attorney]

[ID Number] 100077481

[Patent Attorney]

[Name] Yoshikazu Tani

[Appointed Attorney]

[ID Number] 100088915

[Patent Attorney]

[Name] Kazuo Abe

[Appointed Attorney]

[ID Number] 100106998

[Patent Attorney]

[Name] Denichi Hashimoto

[Fee]

[Deposit Account Number] 013424

[Amount of Deposit] 21,000 yen

[List of Documents Filed]

[Name of Document] Specification 1

[Name of Document] Drawings 1

[Name of Document] Abstract 1

[Number of General Power of Attorney] 9707403

[Requirement of Proof] Required

[Document Title] Specification

[Title of the Invention] Perpendicular Magnetic Recording Medium and Manufacturing Method Thereof

[Claims]

[Claim 1] A perpendicular magnetic recording medium in which at least an antiferromagnetic layer, a soft magnetic layer, a magnetic recording layer, a protective layer and a liquid lubricant layer are formed on a nonmagnetic substrate;

the perpendicular magnetic recording medium characterized by having:

an orientation controlling layer that is made of a material comprising at least Ni and Fe and having at least one element selected from the group consisting of B, Nb and Si added thereto, and is formed immediately below said antiferromagnetic layer; and

a seed layer that is made of Ta, and is formed immediately below said orientation controlling layer.

[Claim 2] The perpendicular magnetic recording medium according to claim 1, characterized by further having an exchange coupling magnetic field controlling layer that is made of an alloy containing at least Fe and Co, and is formed between said antiferromagnetic layer and said soft magnetic layer.

[Claim 3] The perpendicular magnetic recording medium according to claim 1 or 2, characterized in that said antiferromagnetic layer is made of an Mn alloy, and said soft magnetic layer is made of an NiFe alloy, a sendust alloy or an amorphous Co alloy.

[Claim 4] The perpendicular magnetic recording medium according to claim 1, 2 or 3, characterized in that the perpendicular magnetic recording medium is disk-shaped, and magnetization of said soft magnetic layer is applied in radial fashion in a radial direction of the perpendicular magnetic recording medium .

[Claim 5] A method of manufacturing a disk-shaped perpendicular magnetic recording medium in which at least an antiferromagnetic layer, a soft magnetic layer, a magnetic recording layer, a protective layer and a liquid lubricant layer are formed on a nonmagnetic substrate;

the method being characterized by comprising the steps of:

carrying out heating to a blocking temperature or above after depositing said antiferromagnetic layer and said soft magnetic layer; and

cooling to the blocking temperature or below in a static magnetic field applied in radial fashion in a radial direction of the medium.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Pertains]

The present invention relates to a perpendicular magnetic recording medium and a manufacturing method thereof, and more specifically to a perpendicular magnetic recording medium for

which magnetic domain wall formation in a soft magnetic layer is suppressed to reduce noise, and a manufacturing method thereof.

[0002]

[Prior Art]

As art for realizing increased recording density in magnetic recording, the perpendicular magnetic recording method is attracting attention as an alternative to the conventional longitudinal magnetic recording method. A perpendicular magnetic recording medium has a magnetic recording layer made of a hard magnetic material, and a backing layer made of a soft magnetic material that has a role of concentrating magnetic flux generated by a magnetic head used in recording to the magnetic recording layer. Spike noise, which is one type of noise that is a problem with a perpendicular magnetic recording medium having such a structure, is known to be due to magnetic domain walls formed in the soft magnetic layer that constitutes the backing layer. To reduce noise with a perpendicular magnetic recording medium, it is thus necessary to suppress magnetic domain wall formation in the soft magnetic backing layer.

[0003]

With regard to controlling magnetic domain walls in a soft magnetic backing layer, for example a method in which a ferromagnetic layer of a Co alloy or the like is formed above or below a soft magnetic backing layer, and is magnetized in a desired direction to fix the magnetization thereof (see, for example, Patent Document 1), and a method in which an antiferromagnetic thin

film is formed and the magnetization is pinned by using exchange coupling (see, for example, Patent Document 2) have been proposed.

[0004]

[Patent Document 1]

Japanese Patent Application Laid-open No. 6-180834 (paragraph no. 0029, Fig. 1)

[0005]

[Patent Document 2]

Japanese Patent Application Laid-open No. 10-214719 (paragraph no. 0009, Fig. 2)

[0006]

[Problems to be Solved by the Invention]

With the method in which control of magnetic domain walls is carried out through exchange coupling with the soft magnetic backing layer using an antiferromagnetic layer as a magnetic domain controlling layer, if sufficient exchange coupling can be obtained, then magnetic domain wall formation in the soft magnetic backing layer can be suppressed, and hence the method is very effective. However, to obtain sufficient exchange coupling, for example as indicated in Patent Document 2, heating treatment is required to bring out the properties of the soft magnetic backing layer after the film formation. This heating treatment must be carried out for a long time while applying a magnetic field in the radial direction, and hence there has been a problem that the method is not suited to mass production.

[0007]

Moreover, with the method in which a backing layer is constituted by forming on top of one another a soft magnetic layer and an antiferromagnetic layer a plurality of times as indicated, for example, in Patent Document 1, the structure of the backing layer is complex, and hence there has again been a problem that the method is not suited to mass production.

[0008]

In view of the problems described above, it is an object of the present invention to provide a perpendicular magnetic recording medium having reduced noise, and a method of manufacturing such a perpendicular magnetic recording medium that is suited to mass production.

[0009]

[Means for Solving the Problems]

In the present invention, to attain the above object, according to claim 1, in the case of a perpendicular magnetic recording medium in which at least an antiferromagnetic layer, a soft magnetic layer, a magnetic recording layer, a protective layer and a liquid lubricant layer are formed on a nonmagnetic substrate, the perpendicular magnetic recording medium is characterized by having an orientation controlling layer that is made of a material comprising at least Ni and Fe and having at least one element selected from the group consisting of B, Nb and Si added thereto, and is formed immediately below the antiferromagnetic layer, and a seed layer that is made of Ta, and is formed immediately below the orientation controlling layer.

[0010]

According to claim 2, in the case of the perpendicular magnetic recording medium according to claim 1, the perpendicular magnetic recording medium is characterized by further having an exchange coupling magnetic field controlling layer that is made of an alloy containing at least Fe and Co, and is formed between the antiferromagnetic layer and the soft magnetic layer.

[0011]

According to claim 3, in the case of the perpendicular magnetic recording medium according to claim 1 or 2, the perpendicular magnetic recording medium is characterized in that the antiferromagnetic layer is made of an Mn alloy, and the soft magnetic layer is made of an NiFe alloy, a sendust alloy or an amorphous Co alloy.

[0012]

According to claim 4, in the case of the perpendicular magnetic recording medium according to claim 1, 2 or 3, the perpendicular magnetic recording medium is characterized by being disk-shaped, and in that magnetization of the soft magnetic layer is applied in radial fashion in a radial direction of the perpendicular magnetic recording medium .

[0013]

According to claim 5, in the case of a method of manufacturing a disk-shaped perpendicular magnetic recording medium in which

at least an antiferromagnetic layer, a soft magnetic layer, a magnetic recording layer, a protective layer and a liquid lubricant layer are formed on a nonmagnetic substrate, the method is characterized by comprising a step of carrying out heating to a blocking temperature or above after depositing the antiferromagnetic layer and the soft magnetic layer, and a step of cooling to the blocking temperature or below in a static magnetic field applied in radial fashion in a radial direction of the medium.

[0014]

[Embodiments of the Invention]

Following is a detailed description of embodiments of the present invention with reference to the drawings. In a perpendicular magnetic recording medium according to the present invention, an orientation controlling layer is provided immediately below an antiferromagnetic layer, this being with an object of improving the crystallinity and orientation of the antiferromagnetic layer and strengthening the exchange coupling magnetic field. A material comprising NiFe having at least one element selected from the group consisting of B, Nb and Si added thereto is used for the orientation controlling layer. Moreover, to improve the crystallinity and orientation of the orientation controlling layer, a seed layer made of Ta is provided. According to the above constitution, compared with a conventional orientation controlling layer made of NiFe or NiFeCr, interdiffusion between Ta atoms, and Ni atoms and Fe atoms at the interface with the seed layer is suppressed. Furthermore, an

initial growth layer of the orientation controlling layer, i.e. a thin part of thickness 0 to 2 nm that has lattice defects and poor crystallinity, is suppressed. The crystallinity and orientation of the antiferromagnetic layer can thus be improved more than with a conventional orientation controlling layer.

[0015]

Furthermore, an exchange coupling magnetic field controlling layer is provided between the antiferromagnetic layer and the soft magnetic layer, this being with an object of strengthening the exchange coupling magnetic field. An alloy containing at least Fe and Co is used for the exchange coupling magnetic field controlling layer.

[0016]

Fig. 1 shows the structure of a perpendicular magnetic recording medium according to an embodiment of the present invention. The perpendicular magnetic recording medium has a structure in which a seed layer 2, an orientation controlling layer 3, an antiferromagnetic layer 4, an exchange coupling magnetic field controlling layer 5, a soft magnetic backing layer 6, a foundation layer 7, a magnetic recording layer 8 and a protective layer 9 are formed in this order on a nonmagnetic substrate 1, and a liquid lubricant layer 10 is further formed thereon. As the nonmagnetic substrate 1, for example a crystallized glass, a strengthened glass, or an Al alloy plated with NiP as used with ordinary magnetic recording media can be used.

[0017]

The seed layer 2 improves the crystallinity and orientation of the orientation controlling layer 3. Ta is preferable as the material. The thickness is preferably not more than 10 nm so that the seed layer 2 will be amorphous or microcrystalline. The orientation controlling layer 3 improves the crystallinity and orientation of the antiferromagnetic layer 4. The material is preferably a material containing at least Ni and Fe having at least one element selected from the group consisting of B, Nb and Si added thereto. The thickness is preferably at least 3 nm so that sufficient crystal growth is observed. For the antiferromagnetic layer 4, an Mn alloy such as FeMn, CoMn or IrMn can be used. There are no particular limitations on the thickness, but this is preferably approximately 2 nm to 30 nm so that a suitable level of exchange coupling is obtained and so as to be suited to mass production.

[0018]

The exchange coupling magnetic field controlling layer 5 improves the exchange coupling magnetic field. As the material, an alloy containing at least Fe and Co such as FeCo, FeCoNi, FeCoB or FeCoNiB can be used. Considering productivity, the thickness is preferably made to be not more than 20 nm. As the soft magnetic backing layer 6, a crystalline system such as an NiFe alloy or a sendust (FeSiAl) alloy, or else an amorphous Co alloy such as CoZrNb or CoTaZr can be used. Regarding the thickness, the optimum value will vary according to the structure and characteristics of the magnetic head used in recording, but considering also productivity,

this thickness is preferably in a range of 10 nm to 500 nm. Assuming a commonly used disk-shaped medium, the magnetization of the soft magnetic backing layer 6 fixed by antiferromagnetic exchange coupling is preferably applied in radial fashion in the radial direction of the substrate as shown in Fig. 2.

[0019]

For the magnetic recording layer 8, a commonly used CoCrPt material, or else a granular magnetic recording layer in which the nonmagnetic grain boundaries that surround the ferromagnetic crystal grains comprise a nonmagnetic nonmetal, an RE-TM alloy such as TbCo, a multilayer film of Co/Pt or Co/Pd, an FePt ordered alloy, or the like can be used. Note that to use the magnetic recording medium as a perpendicular magnetic recording medium, the ferromagnetic crystal grains must have perpendicular anisotropy relative to the film plane. Moreover, the foundation layer 7 can be provided as appropriate in accordance with the material of the magnetic recording layer.

[0020]

For the protective layer 9, for example a thin film comprising mainly carbon can be used. For the liquid lubricant layer 10, for example a perfluoropolyether lubricant can be used.

[0021]

As a method of manufacturing the perpendicular magnetic recording medium, a method can be used in which heating is carried out to the blocking temperature or above, which is the temperature at which the antiferromagnetic exchange coupling is lost, and then

cooling is carried out down to the blocking temperature or below in a static magnetic field controlled, for example, using permanent magnets. This method is used with an objective of controlling the magnetization direction of the soft magnetic backing layer 6 to all be in a single direction. In the case of carrying out the heating after depositing the antiferromagnetic layer 4 and the soft magnetic backing layer 6 but before depositing the magnetic recording layer 8, if the heating temperature exceeds the blocking temperature, then the antiferromagnetic exchange coupling will disappear, and hence the soft magnetic backing layer 6 magnetization fixing effect will be lost. If even a slight external magnetic field is applied in this state, then the magnetization of the soft magnetic backing layer 6 will be disordered, and magnetic domain walls will arise. When the temperature drops to the blocking temperature or below and hence exchange coupling arises once again, the magnetization will then become fixed as is. A method is thus used in which the magnetic recording medium is held in a static magnetic field while cooling down to the blocking temperature or below. According to this method, the soft magnetic backing layer 6 magnetization fixing effect can be obtained over the whole of the substrate. The strength of the static magnetic field must be such that the magnetization of at least the exchange coupling magnetic field

controlling layer 5 and the soft magnetic backing layer 6 reaches saturation, and is preferably approximately 50 to 1000 Oe.

[0022]

Following are examples of the present invention. Note that the present invention is not limited to the following examples, but rather various modifications can be made so long as the gist of the present invention is not deviated from.

[0023]

(Example 1)

Using a chemically strengthened glass substrate having smooth surfaces (for example, an N-10 glass substrate made by Hoya) as the nonmagnetic substrate, this was washed and then put into a sputtering apparatus. A Ta seed layer was deposited to a thickness of 5 nm using a Ta target, and then an NiFeB orientation controlling layer was deposited to a thickness of 10 nm using an $Ni_{12}Fe_3B$ target. Heating was then carried out using a lamp heater until the substrate surface temperature was 350°C, and then an IrMn antiferromagnetic layer was deposited to a thickness of 10 nm using an $Ir_{80}Mn$ target, and then a CoZrNb amorphous soft magnetic backing layer was deposited to a thickness of 100 nm using a Co_4Zr_8Nb target.

[0024]

Next, a Ti foundation layer was deposited to a thickness of 10 nm using a Ti target, and then a CoCrPt magnetic recording layer was deposited to a thickness of 20 nm using a $Co_{20}Cr_{10}Pt$ target. Heating was then carried out again using a lamp heater until the substrate surface temperature was 350°C, and then immediately

afterward cooling was carried out to 150°C in a 1000 Oe fixed magnetic field. Finally, a protective layer was deposited to a thickness of 10 nm using a carbon target, and then the magnetic recording medium was removed from the vacuum apparatus. The deposition of all of the layers was carried out by DC magnetron sputtering under an Ar gas pressure of 5 mTorr. Afterward, a 2 nm liquid lubricant layer made of a perfluoropolyether was formed using a dipping method, thus producing the perpendicular magnetic recording medium.

[0025]

(Example 2)

A perpendicular magnetic recording medium was produced as in Example 1, except that the orientation controlling layer was deposited to a thickness of 10 nm using an $Ni_{12}Fe_9Nb$ target.

[0026]

(Example 3)

A perpendicular magnetic recording medium was produced as in Example 1, except that the orientation controlling layer was deposited to a thickness of 10 nm using an $Ni_{12}Fe_4Si$ target.

[0027]

(Example 4)

A perpendicular magnetic recording medium was produced as in Example 1, except that after depositing the IrMn antiferromagnetic layer but before depositing the CoZrNb soft magnetic backing layer, a CoFe exchange coupling magnetic field controlling layer was deposited to a thickness of 2 nm using a $Co_{10}Fe$

target.

[0028]

(Example 5)

A perpendicular magnetic recording medium was produced as in Example 2, except that after depositing the IrMn antiferromagnetic layer but before depositing the CoZrNb soft magnetic backing layer, a CoFe exchange coupling magnetic field controlling layer was deposited to a thickness of 2 nm using a $Co_{10}Fe$ target.

[0029]

(Example 6)

A perpendicular magnetic recording medium was produced as in Example 3, except that after depositing the IrMn antiferromagnetic layer but before depositing the CoZrNb soft magnetic backing layer, a CoFe exchange coupling magnetic field controlling layer was deposited to a thickness of 2 nm using a $Co_{10}Fe$ target.

[0030]

(Example 7)

A perpendicular magnetic recording medium was produced as in Example 4, except that the exchange coupling magnetic field controlling layer was deposited using a $Co_{13}Ni_{22}Fe$ target.

[0031]

(Example 8)

A perpendicular magnetic recording medium was produced as in Example 5, except that the exchange coupling magnetic field

controlling layer was deposited using a $Co_{13}Ni_{22}Fe$ target.

[0032]

(Example 9)

A perpendicular magnetic recording medium was produced as in Example 6, except that the exchange coupling magnetic field controlling layer was deposited using a $Co_{13}Ni_{22}Fe$ target.

[0033]

(Example 10)

A perpendicular magnetic recording medium was produced as in Example 4, except that the exchange coupling magnetic field controlling layer was deposited using a $94(Co_{13}Ni_{22}Fe)6B$ target.

[0034]

(Example 11)

A perpendicular magnetic recording medium was produced as in Example 5, except that the exchange coupling magnetic field controlling layer was deposited using a $94(Co_{13}Ni_{22}Fe)6B$ target.

[0035]

(Example 12)

A perpendicular magnetic recording medium was produced as in Example 6, except that the exchange coupling magnetic field controlling layer was deposited using a $94(Co_{13}Ni_{22}Fe)6B$ target.

[0036]

(Comparative Example 1)

A perpendicular magnetic recording medium was produced as in Example 1, except that the Ta seed layer was not deposited.

[0037]

(Comparative Example 2)

A perpendicular magnetic recording medium was produced as in Example 1, except that the NiFeB orientation controlling layer was not deposited.

[0038]

(Comparative Example 3)

A perpendicular magnetic recording medium was produced as in Example 1, except that the Ta seed layer, the NiFeB orientation controlling layer, the IrMn antiferromagnetic layer and the CoZrNb soft magnetic backing layer were not deposited.

[0039]

For each of the examples and comparative examples, to ascertain whether or not there were magnetic domain walls formed in the soft magnetic backing layer, using a spin stand tester, an evaluation was carried out by carrying out reading in a state in which signals had not been written. Reading was carried out for 100 revolutions of the disk, and the ratio of the fluctuation to the mean value of the output was taken as the COV (%). Spike noise from magnetic domain walls is detected as a locally large signal output, and in the case that the magnetic domain walls are wavering the size of this signal output fluctuates; it is thus considered that the larger the COV value, the more spike noise is occurring.

[0040]

Moreover, to investigate the size of the exchange coupling magnetic field, samples were produced for which the steps of depositing the Ti foundation layer and the CoCrPt magnetic

recording layer were omitted from the perpendicular magnetic recording medium manufacturing process. For these samples for each of the examples and comparative examples , the magnetization curve was measured in the radial direction of the substrate using a vibrating sample magnetometer, and the exchange coupling magnetic field was calculated from the M-H loop obtained. The results are shown in Table 1.

[0041]

[Table 1]

	Seed layer	Orientation controlling layer	Exchange coupling magnetic field controlling layer	Exchange coupling magnetic field (Oe)	COV (%)
Example 1	Ta	NiFeB	-	18.1	6
Example 2	Ta	NiFeNb	-	17.5	7
Example 3	Ta	NiFeSi	-	17.1	7
Example 4	Ta	NiFeB	CoFe	27.6	5
Example 5	Ta	NiFeNb	CoFe	27.1	5
Example 6	Ta	NiFeSi	CoFe	26.5	5
Example 7	Ta	NiFeB	CoFeNi	29	5
Example 8	Ta	NiFeNb	CoFeNi	28.4	5
Example 9	Ta	NiFeSi	CoFeNi	28.6	5
Example 10	Ta	NiFeB	CoFeNiB	31.4	5
Example 11	Ta	NiFeNb	CoFeNiB	31.2	5
Example 12	Ta	NiFeSi	CoFeNiB	30.4	5
Comparative Example 1		NiFeB	-	8.2	11
Comparative Example 2	Ta	-	-	0	23
Comparative Example 3	-	-	-	-	5

[0042]

The relationship between the size of the exchange coupling magnetic field and the layer structure will now be discussed. Comparing Example 1 and Comparative Example 2, with Comparative Example 2 in which there was no NiFeB orientation controlling layer,

the exchange coupling magnetic field was 0, i.e. exchange coupling did not occur, and hence the necessity of the orientation controlling layer is clear. Comparing Example 1 and Comparative Example 1, with Example 1 in which there was a Ta seed layer, an increase in the exchange coupling magnetic field was seen. With Example 2 in which NiFeNb was used, and Example 3 in which NiFeSi was used, for the orientation controlling layer instead of the NiFeB in Example 1, exchange coupling comparable to that for Example 1 occurred. Furthermore, with Examples 4 to 6 in which a CoFe exchange coupling magnetic field controlling layer was added, Examples 7 to 9 in which a CoNiFe exchange coupling magnetic field controlling layer was added, and Examples 10 to 12 in which a CoNiFeB exchange coupling magnetic field controlling layer was added, the exchange coupling magnetic field was increased compared with Examples 1 to 3.

[0043]

Next, the relationship between the size of the exchange coupling magnetic field and the COV will be discussed. With Comparative Example 3 in which there was no soft magnetic backing layer, spike noise could not occur, and the COV was 5%. On the other hand, with Examples 4 to 12 for which the exchange coupling magnetic field was at least 27 Oe, the COV was similarly 5%, and hence it can be seen that spike noise was completely suppressed. Moreover, from Examples 1 to 3 and Comparative Examples 1 and 2,

it can be seen that the higher the exchange coupling magnetic field, the lower the COV.

[0044]

[Effects of the Invention]

As described above, according to the present invention, a perpendicular magnetic recording medium has an orientation controlling layer that is made of a material comprising at least Ni and Fe having at least one element selected from the group consisting of B, Nb and Si added thereto, and a seed layer that is made of Ta, and is formed immediately below the orientation controlling layer. As a result, the crystallinity and crystal orientation of the antiferromagnetic layer can be improved, and hence the exchange coupling magnetic field can be strengthened, and thus it becomes possible to suppress spike noise.

[0045]

Moreover, according to the present invention, the perpendicular magnetic recording medium preferably further has an exchange coupling magnetic field controlling layer that is made of an alloy containing at least Fe and Co, and is formed between the antiferromagnetic layer and the soft magnetic backing layer. As a result, the exchange coupling magnetic field can be further increased, and thus it becomes possible to further improve the suppression of spike noise.

[Brief Description of the Drawings]

[Fig. 1]

A schematic drawing showing the structure of a perpendicular magnetic recording medium according to an embodiment of the present invention.

[Fig. 2]

A schematic drawing illustrating the application of a magnetic field in the radial direction of the substrate of a perpendicular magnetic recording medium.

[Explanation of Reference Numerals]

1 Nonmagnetic substrate

2 Seed layer

3 Orientation controlling layer

4 Antiferromagnetic layer

5 Exchange coupling magnetic field controlling layer

6 Soft magnetic backing layer

7 Foundation layer

8 Magnetic recording layer

9 Protective layer

10 Liquid lubricant layer

[Document Title] Abstract

[Abstract]

[Problem] To provide a perpendicular magnetic recording medium and a manufacturing method thereof, that are suited to mass production, and according to which spike noise is suppressed.

[Means of Solution] In the case of a perpendicular magnetic recording medium in which at least an antiferromagnetic layer 4, a soft magnetic layer 6, a magnetic recording layer 8, a protective layer 9 and a liquid lubricant layer 10 are formed on a nonmagnetic substrate 1, the perpendicular magnetic recording medium has an orientation controlling layer 3 that is made of a material comprising at least Ni and Fe and having at least one element selected from the group consisting of B, Nb and Si added thereto, and is formed immediately below the antiferromagnetic layer 4, and a seed layer 2 that is made of Ta, and is formed immediately below the orientation controlling layer 3.

[Chosen Drawing] Fig. 1

Text in Drawings

Fig. 1

LIQUID LUBRICANT LAYER 10

PROTECTIVE LAYER 9

MAGNETIC RECORDING LAYER 8

FOUNDATION LAYER 7

SOFT MAGNETIC BACKING LAYER 6

EXCHANGE COUPLING MAGNETIC FIELD CONTROLLING LAYER 5

ANTIFERROMAGNETIC LAYER 4

ORIENTATION CONTROLLING LAYER 3

SEED LAYER 2

NONMAGNETIC SUBSTRATE 1

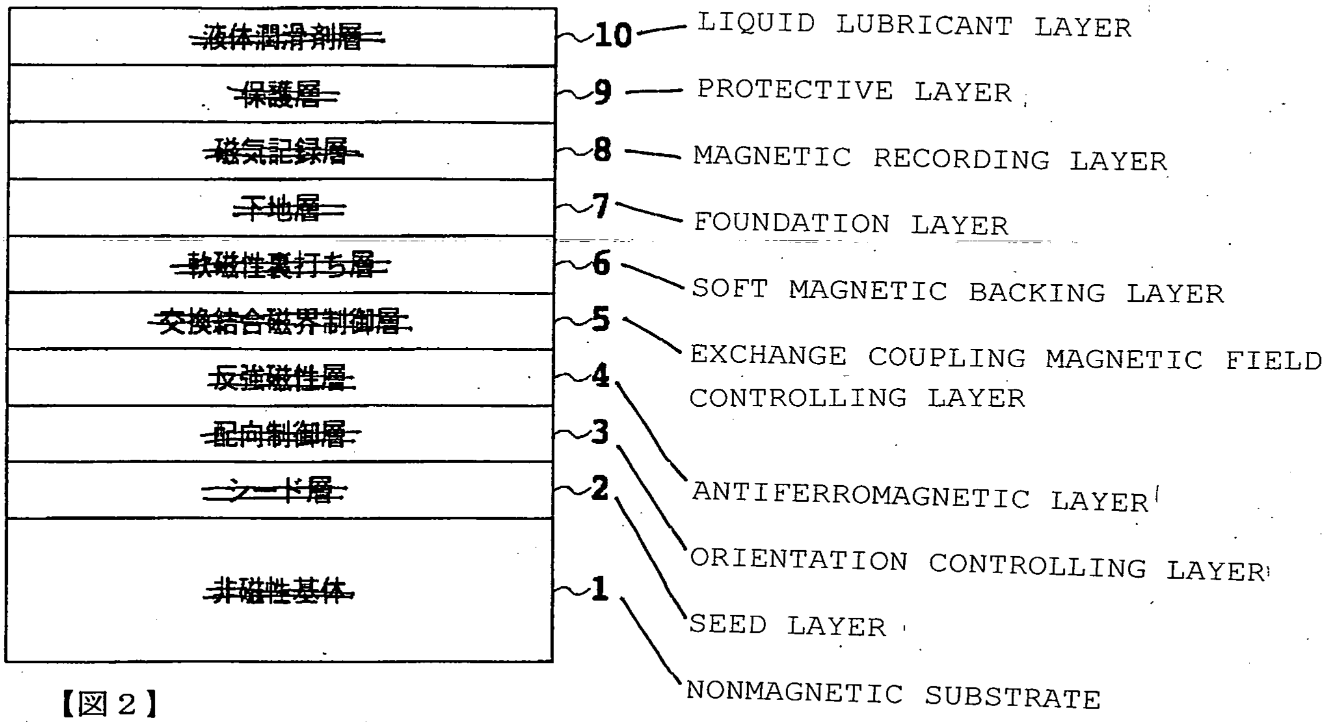
Fig. 2

N POLE

S POLE

【書類名】　　　図面　　~~Please Translate~~

【図１】



【図２】